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The Effect of Teaching Approaches on the Pattern of Pupils' Cognitive Structure: Some Evidence from the Field

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In this study, the effect of different teaching approaches on pupils' cognitive structures (N=110) in the topic of circulation system was investigated by using the Word Association Test (WAT). WAT was administered as a pre-test and post-test to all groups. The control group was taught by lecturing. In addition to lecturing, concept maps were used in the first experimental group and the cooperative learning approach was used in the second experimental group. In order to map the pupils' cognitive structures, response frequencies in the WAT were used. The results showed that: i) pupils generated more response words for the majority of the key words in the post-WAT than they did in the pre-WAT; and ii) there was not any observable difference in the pre-WAT mind maps of all the groups in terms of complexity and branching. However, the post-WAT mind maps clearly showed considerable difference regarding complexity and branching. In other words, the teaching approach may seem to affect the associations between concepts in the pupils' minds. Implications of the results for better teaching and meaningful learning are critically discussed.

Keywords: Word association test, teaching approaches, cognitive structure, circulation system.

It is tenable to believe that any information and understanding can be transferred intact from the teacher to the learner. The more plausible view is that every learner uniquely reconstructs his/her knowledge and understanding from the information the teacher presents, in the light of the knowledge and understanding she/he already has in the cognitive structure (Bahar, Johnstone, & Hansell, 1999). There is enormous literature and some differences about constructivist views of learning; however, the following points are commonly emphasized in the literature: i) learners are active builders of knowledge who interact with their environment and with other individuals in their environment; ii) construction of a new knowledge based on the existing knowledge is an individual act; however, language and the social structure shape the individual constructions to some extent; and, iii) learning is a change in the learners' conceptions and learners make sense of the reality by first assimilating the coming information into the already existing cognitive structure. However, this process may not be successful all time. In this case the cognitive structure has to be further developed (Ausubel, 1968; Brooks & Brooks, 1993; Driver & Bell, 1986; von Glaserfeld, 1989; Vygotsky, 1978;)

The cognitive structure is a hypothetical construction showing the relationships between concepts in a learner's long term memory (Shavelson, 1974). The cognitive structure contains the learners' existing experiences and knowledge that will dominate their reconstruction and information processing of the incoming stimuli (Tsai, 2001). A variety of methods have been used to explore the cognitive structure of the students such as concept maps (Novak & Gowin, 1984; Kinchin & Hay 2000), concept circles (Wandersee, 1987), flow map (Anderson & Demetrius, 1993; Tsai, 2001), tree construction (Jonassen, Beissner & Yacci, 1993). Word Association Test (WAT) is one of the most common and oldest methods that have been used by several researchers to investigate the cognitive structures (Deese, 1965; Shavelson, 1974; Kempa & Nicholls, 1983; Johhnstone & Moynihan, 1985; Cachapuz & Maskill, 1987; Bahar, Johnstone & Sutcliffe, 1999; Özatlý, 2006). The underlying assumption in a WAT is that the order of the response retrieval from long term memory reflects at least a significant part of the structure within and between concepts (Shavelson, 1974). In a WAT, the degree of overlap of response hierarchies is a measure of the semantic proximity of the key words (Deese, 1965). In several studies (Kounious & Holcomb, 1992; Ashraft, 1994) a great regularity in semantic memory structure is reported. The more related the concepts are, the faster the mental search process which retrieves information about the concepts is. This may explain the importance of the order of the students' responses for each key word. WAT is based on the assumption that giving a key word and asking the respondent to freely associate what ideas come to his or her mind gives relatively unrestricted access to mental representations of the key term (Hovardas & Korfiadis, 2006).

It has been declared that ideas expressed within a word association procedure are spontaneous productions subject to fewer constraints than typically imposed in interviews or closed questionnaires, thus, allowing the extraction of less biased results (Wagner, Valencia, & Elejabarrieta, 1996). Hovardas and Korfiadis, (2006) states that WAT is a heuristically promising approach, allowing for the precise estimation of important aspects of conceptual restructuring like the validity and the extent of the concepts used, as well as the coherence and the availability of the emerging conceptual structure. Word association tasks accompanied by content analysis, and structural and narrative reconstruction processes do not only reveal the students' conceptual reservoir potential and validity but also are quite capable of unraveling the complexity of conceptual constructs which can be described by structural frameworks as well as narrative interrelations. Tsai and Huang (2002) differentiate a free word association and a controlled word association. In the free word association, subjects are offered a key concept and are asked to write down all relevant concepts freely without a time limit. Whereas in the controlled word association, the subjects are offered a key concept and are asked to write down some relevant concepts within one minute, meaning, they have to choose their responses according to the importance of the key concept. In both techniques, a complex matrix calculation is needed. In other words, to measure of the commonality of the response words for the key words, the number of common words and their rank orders are taken into consideration.

Kempa and Nicholls (1983) used the WAT to look at the relationship between students' cognitive structures and their problem solving abilities in the context of chemistry. They reported that the more branched and networked the knowledge and understanding in a student's mind is, the more accessible it is and the more effective it is for non-routine problem solving. In the context of chemistry by using WAT responses of the students, Johnstone and Moynihan (1985) also indicated that if a pupil possesses an unstable cognitive structure in a particular subject area, then problem solving will be inhibited in that area. In the context of introductory biology, Bahar and Ozatli (2003) used WAT to detect changes between pre- and post-instruction or, in other words, to see the conceptual growth. During instruction, as a teaching approach, lecturing and discussion were used together to only one group of students (N=60). Students were given the WAT twice, both before instruction (pre-WAT) and after instruction (post-WAT). Pre-WAT results showed that students had some prior knowledge although they had not been exposed to any formal teaching about these topics. In terms of complexity of the networks and associations between key words and their responses, the most obvious feature of the pre-WAT was the isolated clusters around the key words. On the other hand, the networks in the post–WAT were more complex, that is, a few isolated clusters which suggest that, as a result of the learning process, conceptual learning had taken place.

Teaching approaches: Because the scope of this study is also related to some particular teaching approaches (e.g., lecturing, concept maps and cooperative learning), it is necessary to give some views about them. In spite of the fact that there have been a tremendous shift towards the student-centred teaching approaches in the curriculum all over the world, lecturing still remains the most widely used teaching approach. In general, lecturing can be described as a traditional way of teaching where the teacher transmits a large quantity of information to the students who acquire the knowledge in passive way. There are three main parts in lecturing: i) an introduction where students' attentions are directed to the topic; ii) a teacher presentation of the topic in an organized way; and, iii) a summary section where main points are emphasized (Ozden, 2000). However, it is necessary to mention that these three stages may not always be found in all lectures. Because of the lack of involvement of the students who remain passive recipients of the information, lectures are seen as an ineffective way to promote higher thinking skills and to form good attitudes (Gibs, Habeshaw, & Habeshaw, 1987; McKiechi, 1994; Knight & Wood, 2005). It mainly carries negative connotations. However, when done effectively, lectures may allow students to learn new materials, explain difficult concepts, organize their thinking, promote problem solving skills, and challenge their attitudes (Gage & Berliner, 1991; Nasmith & Steinert, 2001). In other words, the effectiveness of the lecturing approach which is seen as a teacher-dominated teaching approach may vary according to its way of implementation.

Concept maps were introduced as educational tools by Novak and members of his research group in the early 1970s as a means of representing frameworks for the interrelationships between concepts (Novak & Gowin, 1984). Concept maps were developed as an outgrowth of Ausubel's theory of meaningful learning (Novak, 1984). A concept map is a pictorial representation of a domain which consists of concepts represented as nodes that are connected to each other by arcs. The concepts are ideas or words which represent events, objects, or even emotions and feelings. The connecting arcs represent the conceptual links between two or more concepts within the concept map. Concept maps were used for different purposes, such as: an assessment tool to measure students' understanding (Bolte, 1999; Ruiz-Primo, Shavelson, Li, & Schultz, 2001), or to reveal prior knowledge or misconceptions students have (Regis, Albertazzi, & Roletto, 1996) or to aid in meaningful learning (Soyibo, 1991; Bahar, 2002) and as a metacognitive tool (Mintzes, Wandersee, & Novak, 1999). According to Kinchin and Hay (2000), in addition to showing what knowledge a student holds, concept maps also illustrate how and what knowledge is arranged in the student's mind. This arrangement of the knowledge and the nature of the links suggest some practical implications for the student's future learning. The construction of a concept map is intended to show the perceptions of the individual, rather than a reproduction of a memorized facts (Jonassen, Reeves, Hong, & Peters, 1997) The structure of a map is, therefore, unique to its author, reflecting his/her beliefs and biases in addition to his/her understanding of the topic. The ability to construct a concept map also illustrates two essential properties of understanding, both the representation and the organization of ideas (Halford, 1993). In a study done by Bahar (2002) it was also seen that students effectively used concept mapping's advantages for better planning and essay writing as an alternative to a linear writing plan. Concept mappings helped most of the students to organize their ideas and aided them in planning their essay on seed germination. However, as with any other techniques, concept maps also do not suit everyone. In Bahar's (2002) study there were some students, albeit a small number, who had higher scores from essay-writing even though they had not drawn quality concept maps as their plans. Hodson (1998) indicates that some students may wish to conceal some aspects of their understanding so their maps would not provide a total insight to the student's perspective. Hence, it is clear from observations of changes in students' maps that such structures are in a continual state of flux in an active learner. In another study done with secondary school chemistry students, it was also reported that visualization indeed seems to result in a positive effect on the learning of students. However, there is no statistically significant effect of concept mapping and of the combination of concept mapping with visualization on the learning (Brandt et al., 2001*)*.

There are some discussions among science educators in Turkey with regard to using concept maps in Turkish. Kilic (2003) argues that there are some problems in Novak's style of concept maps in Turkish which are caused by linguistic differences between the Turkish and English languages. The main problem is related to the subject-object-verb order in Turkish compared to the subject-verb-object order in English. Instead of Novak's style, Kilic offers three alternative methods, namely: writing the relationships between concepts as a complete sentence on a connecting line; explaining relationships between concepts in a short paragraph below a concept map; or, explaining the concept map verbally. However, there are also several research studies reported in Turkish science education literature using concept maps in Novak's style without mentioning any significant problems (Sahin, 2001, 2002; Kilic & Saglam, 2004; Koca & Sen, 2004; Ozatli, 2006). Therefore, students' training period of developing concept maps, their first experiences about concept maps, even teachers' attitudes towards using concept maps (because some teachers may not adopt to using them) may have an effect of adopting and using concept maps in the classroom and as an extracurricular tool for life long learning.

Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each other's learning (Johnson, Johnson, & Holubec, 1993). Several techniques were developed in cooperative learning such as Jigsaw (Slavin, 1990), Co-op (Kagan, 1994), student teams-achievement divisions (Slavin, 1990; Priest, 1994), teams-games-tournament (Priest & Stahl, 1994), and learning together (Johnson and Johnson, 1999). However, there are certain essential elements that are mentioned in the studies related to cooperative learning. These include a clear set of specific student learning outcome objectives, believing the goals by all students, heterogeneous groups, equal opportunity for success, positive interdependence, face-to-face interaction, sufficient time for learning, individual accountability, and reflection and evaluation of group behaviours and performance) Johnson and Johnson (1989, 1999) performed a major analysis of studies in which researchers compared the performances of the students educated by using cooperative learning strategies with that of students taught by traditional methods, such as the lecturing method. The results of their analysis clearly showed that cooperative learning promoted higher individual knowledge than did competitive and individualistic learning, whether the task required verbal, mathematical or physical skills. There are additional benefits in cooperative learning, namely: students have higher proficiency in critical reasoning strategies and abilities; they have higher levels of intrinsic motivation to learn; and, they possess many of the positive attitudes necessary for working effectively with others (Stahl, 1996). Knight and Wood (2005) also mentioned that even a moderate shift towards more interactive and cooperative learning in a class can result in significantly higher student learning gains than what can be achieved using a standard lecture format. Basili (1989) observed that the students of a community college had fewer misconceptions (i.e., ideas that are scientifically not true) in chemistry following cooperative learning in comparison with other instructional methods. Cooperative group work on concept-focused tasks can provide a viable environment for adult learners to overcome their misconceptions in chemistry (Basili & Sanford, 1991).

Despite the enormous benefits of cooperative learning, just like any other educational tool, cooperative learning may also have some weaknesses and problems. According to Randall (1999), the many benefits of cooperative learning sometimes blind us to its drawbacks. In Randall's view, group members are responsible for each other's learning which may place too great a burden on some students. In mixed ability groups, the result is often that better students are left to teach weaker students and do most of the work. In addition, in small groups, there is sometimes only enough time to focus on the task at its most basic level. This may encourage only lower level thinking and may be the cause for ignoring the strategies necessary for the inclusion of critical or higher level thinking. Gender inequities might be another problem in cooperative learning. The results of several researches (Cohen, 1994; Linn & Burbules, 1993) show that in science and perhaps in other areas of the curriculum as well, group learning may be less equitable for girls than autonomous learning. Group learning may reinforce stereotypes, biases, and views of science and math as a male domain. On the other hand, Brown, Chesney-Lind & Stein (2006) states that girls are outperforming boys because schools are privileging girl subjects, such as reading and writing, and girls' ways of doing things, like cooperative learning and sitting at the desks. Soyibo and Evans (2002) also reported that, on the topic of human nutrition, the use of the method of learning together improved significantly the understanding of the students more than with the use of the lecture method., However, there were not any differences in the post-test in terms of attitudes towards biology. Although the effect might be negligible, some individual differences may also effect the negative attitudes towards group work. For example, independent students with cognitive styles who can easily break up an organized field and separate relevant information from its context, or discern 'signal' (what matters) from 'noise' (the incidental and peripheral) in a confusing background prefers individualistic studies rather than group works (Bahar & Hansell, 2000; Johnstone & Al-Naeme, 1991).

METHOD

Sample: This study was conducted in a primary school that could be considered as a moderate ranking school in Istanbul in terms of its location and performance in the general placement exam for high schools. A total of 110 pupils between 12 and 13 years of age in three different groups of Grade 6 (6A, 6B, 6C) participated in the study. The number of boys and girls in all three groups are almost equal. The pupils in 6/B (N=37) were taught with the lecturing approach (the control group); the pupils in 6/A (N=38) were taught, using the lecturing approach as well with concept maps (the first experimental group); and pupils in 6/C (N=35) were taught using the cooperative learning approach (the second experimental group). A total of nine hours of teaching time were spent for each group in the study. The time allocated for the teaching of the circulation system in the science and technology curriculum is nine hours as well. The teaching phase of the study took three weeks as there were three hours of science in the curriculum a week. The teacher, having taught the same subject matter previously, was also quite sure that the time allocated was sufficient for the teaching of the subject matter. It is important to mention that all the groups were randomly formed, mixed ability classes.

Procedure followed during instruction: The lecturing approach was applied in the control group. Before instruction, the pupils were asked several questions regarding the circulation system to explore their prior knowledge as well as to motivate them. This knowledge was taken into consideration during instruction. Then, the theoretical knowledge in the textbook was covered by the teacher. In addition, in accordance with the objectives in the science curriculum, particular activities such as the dissection of a sheep heart and the observation of the blood sample were performed. All these practical activities were conducted in similar but different formats. In other words, the activities were done in group work or on an individual basis, or were conducted by the researcher in front of the pupils. At the end of each lesson, an oral summary was given to highlight the main points in the subject matter. Also, the questions were directed to the pupils to make sure that the subject matter was clear enough for them.

In the first experimental group, until the end of the instruction, similar procedures were followed which was also the case in the control group. The pupils were then required to construct a concept map individually at the end of each lesson. (It is important to mention that the pupils in both experimental groups had already been taught how to draw a concept map in their previous units.) After that, each individual compared his/her concept map with their peer. Then, the instructor constructed a general concept map by getting the whole class to participate. (This concept map is given in Appendix 1). In this process, the instructor played the role of the facilitator only. As was the case in the control group, an oral summary was given to the entire class in order to highlight the main points in the subject matter at the end.

As already mentioned in the introduction part, although different techniques are mentioned in the literature, the teacher may choose a number of ways to apply the cooperative learning as long as he/she takes into account the important elements of cooperative learning. In the second experimental group, the pupils were formed into groups of four. In addition, the heterogeneity in the groups (e.g., gender, ability, etc.) was taken into consideration when the groups were formed. Also, the pupils were given necessary information about the cooperative learning. In this group, from the beginning to the end of the instruction, the essential elements of cooperative learning were taken into consideration and the following procedure was applied. First, the pupils were grouped in fours, and the heterogeneity within the groups was taken into consideration. Second, a class discussion was conducted in the beginning to reveal the pupils' prior knowledge and to stimulate their curiosity regarding the subject matter. At this stage, each group was asked to take notes of the important points that were mentioned during the discussion. Third, each group member selected one aspect of the subject matter presented by the instructor and she/he individually gathered information and organized the materials. These subtopics were then presented to the other group members. At this stage, a concept map was drawn for the subject matter presented. Following that, the other members of the groups made a critical evaluation of the presentation, and the necessary amendments were made. Then, each aspect of the subject matter was noted, and a common document was prepared. At the end, a group concept map was drawn with the participation of all the members of the group, and the work sheets related to the subject matter were worked out. (One of the examples of a group concept map is given in Appendix 2). Finally, an evaluation is done regarding the individual presentations as well as the group ones so that individual and group reflections could be achieved. It is important to mention that the practical activities were done in a similar format in both the control group and in the first experimental group.

Word Association Tests: In order to construct the WAT, the eleven key words that the topic circulatory system is based on were selected. All these key concepts acted as stimuli. These key concepts were *circulation, heart, blood, blood vessel, big circulation, small circulation, blood cells, blood clotting, blood groups, lymphatic system* and *heart healthiness*. For each key word, pupils were required to list up to ten response words that they considered to be most closely associated with that key word. For the response of each key word, a time of 30 seconds that is thought as optimum (Bahar, 1999) were given. The time allotted for each key word was controlled by the researchers. In the response form, each key word was written at the top of the page and ten times down the side of the page so that pupils were encouraged to return to the key word after each association to minimize the chaining effect, in which each response, rather than the key word, becomes the key to the next response. In order to minimize these kinds of problems, pupils were given necessary instructions about the Word Association Test and a WAT application was made as an example. The WAT were applied at the beginning (the Pre-WAT) and at the end of the subject matter (the Post-WAT).

The most common method of analyzing the responses to the key words is to measure the number of common words between responses to pairs of key words and their rank orders. As previously mentioned in the Introduction, this is attempted in the formula by Garskoff and Houston (1963) to generate a relatedness coefficient, which could range from a value of 1 (perfect relatedness; possibly a synonym) to a value of 0 (totally unrelated). This formula was used by several researchers. In this study, another way of looking for relations that was offered by Bahar, et al. (1999) was adopted. In this procedure, the valid response words for each key word are counted and a frequency table is prepared. The words used in the count were taken to be "valid" if they are meaningful and acceptable in terms of the topic circulation system. By using these frequencies, an informative map showing the relationships between key concepts and the responses are drawn. It is thought that this procedure yields a more complex map than the relatedness coefficient method; however, it is very informative in terms of the structure and the complexity of the pupils' mind (Bahar, et al., 1999). To draw the mind map by using the frequency values in the frequency table, the following procedure was applied. The highest frequency in the table was identified. Then a cut-off point that was lower than the highest frequency was determined. The frequencies that were equal to and/or higher than the cut-off point were shown as in the Figure 1, cell one. Then the cut-off points were lowered step by step, and each time the associations between key words and response words were drawn. This procedure was continued until it reached the point where all the key words had joined the picture.

RESULTS AND DISCUSSIONS

One of the methods of summarizing WAT data is to count the number of responses to each key word (Shavelson, 1974). The number of different responses for a word is a significant and direct indication of an individual's understanding of the word, as meaning might be defined as being proportional to the number and the complexity of the links the individual can make to the word (Bahar, et al., 1999). Therefore, the pre- and the post WAT results should differ in terms of the number of different responses to each key word. In other words, higher number of different responses to key words is expected in the post-WAT. Table 1 shows the total number of different response words to each key word in the pre- and post WAT.

As seen in Table 1, no considerable difference was observed in terms of the total number of different response words for each group in the pre-WAT. This might strengthen the idea that the pupils in all groups had similar levels of prior knowledge of the subject matter. In addition, the similarities between the higher number of the total different response words in the pre-WAT may also indicate that the pupils had considerable amount of prior knowledge which may have come partially from their prior learning experiences. These experiences could be categorised as either scientifically true or untrue, and which were obtained from sources such as direct observation of the event, newspapers, peer groups, etc. In both cases, it is important to take prior knowledge into consideration since it acts as a basis for the

Table 1

Total number of different response words to each key word in the pre-WAT and the post-WAT and their difference

Key words	Control group *Pre-WAT* and Post-WAT	1st experimental group *Pre-WAT* and Post-WAT	2nd experimental group*Pre-WAT* and Post-WAT
Circulation	*9*-25 (+16)	*17*-30 (+13)	*13*-26 (+13)
Hearth	*22*-37 (+15)	*26*-33 (+7)	*21*-28 (+7)
Blood	*29*-36 (+7)	*22*-33 (+11)	*20*-28 (+8)
Blood vessel	*24*-34 (+10)	*30*-31 (+1)	*28*-27 (-1)
Systemic circulation	*16*-29 (+13)	*15*-29 (+14)	*15*-22 (+7)
Pulmonary circulation	*17*-30 (+13)	*12*-24 (+12)	*13*-26 (+13)
Blood cells	*23*-37 (+14)	*24*-44 (+20)	*23*-27 (+4)
Clotting	*19*-26 (+7)	*18*-20 (+2)	*13*-24 (+11)
Blood group	*20*-20 (0)	*21*-25 (+4)	*22*-20 (-2)
Lymphatic system	*17*-23 (+6)	*17*-26 (+9)	*11*-32 (+21)
Hearth healthiness	*38*-50 (+12)	*30*-32 (+2)	*31*-33 (+2)
Total number of different response words	*79*-91 (+12)	*74*-75 (+1)	*75*-76 (+1)

Note: The key words are given in order as in WAT sheet. The numbers in brackets shows the difference between the pre- and the post WAT responses.

reconstruction of the knowledge and understanding in the cognitive structure. In the pre-WAT, compared with other key words, the response words for the key words "circulation, systemic circulation, pulmonary circulation, clotting, and lymphatic system" were lower than the others for all three groups. The higher number of different responses for the key words "Healthiness of heart, heart, blood, and blood vessel" might be related to their everyday usage. When compared with other key words, they are much more frequently used and mentioned in informal speeches as well as in the newspapers and magazines. Pupils seemed to be more familiar with the words associated with these latter four key words.

In terms of the post-WAT results, the total number of different response words for the entire set of key words was almost the same for the first and the second experimental groups. However, the number of the control group's post-WAT response words increased more than the other two groups'. In addition, in terms of the response words for each key word, as expected, there were significant increases for some key words (e.g., circulation, systemic circulation, lymphatic system, and blood cells) for all groups. However, there was almost no change in some key words such as "blood group" for the control group, "blood vessel, clotting, heart healthiness" for the first experimental group, and "blood vessel, blood group and heart healthiness" for the second experimental group. This result may be explained as follows. As was previously mentioned, the meaningfulness of the key words might be proportional not only to the number of the response words, but also to the number of "valid" response words associated with the key word. A look at the frequency table, which consists of the number of total response words and their frequencies for each key word, would show that for the control group, in particular, some response words that were not significant in terms of showing the pupils' understanding of the subject matter in the pre-WAT also appeared in the post-WAT. For instance, the response words "emotion, love, liver" for the heart, "alcohol, drinks, fruits and vegetables" for the heart healthiness, "feet, blue" for the blood, and "freezing" for the blood clotting were given in the pre- and the post-WAT in the control groups. These responses indicated that even though the teacher-dominated lecturing approach was used, the pupils continued to use those words. It seems logical to assume that, without any connections, a word is relatively meaningless and its meaning is enriched as more connections are formed (Schafer, 1979; White & Gunstone, 1992). However, the validity of connections seem to be more important than the quantity of the response words.

In this context, the following questions may also be considered. Why does the number of invalid responses seem to be higher in the control group? Is there any difference related to the teaching approach? In spite of the fact that the effectiveness of teacher-dominated lecturing may have varied in terms of implementation, the pupils, who remained passive recipients of information, may have tended to keep their prior knowledge in the lecturing approach more than in the concept mapping and cooperative learning approaches. However, it is important to mention that this claim is made only for the keeping of the response words associated with the key words despite instructional intervention. Therefore, the inferences to be made regarding the understanding of the subject matter from the response lists may require more evidence.

As mentioned before, by using the frequency of the response words to each key word a mind map can be drawn. This map reveals the richness of the response words as well as the structure of the associations between key words and the responses which were the reflections of the cognitive structure in the pupils' minds. Figures 1, 2, and 3 show the pre-WAT mind maps of the control, first experimental, and second experimental groups, respectively. As seen in all these figures, the following points can be emphasized: i) no associations appeared in the first cell of the mind maps (cut off point of 25 and over) for the control and second experimental groups; ii) there was only one response word that connected two or three key words to each other such as the response word "life" between heart and blood vessel in the control group; and the response word "human" between heart, heart healthiness, and blood; iii) even in the last cell (cut off point of 10-14) of the mind maps of all groups, eight or nine key words out of eleven appeared. In the control group's mind map, the key words "blood cells, lymphatic system, and healthiness of heart"; in the first experimental group the key words "blood cells and lymphatic system", and in the second experimental group the key words "lymphatic system, blood clotting, and pulmonary circulation" did not appear; and, iv) the mind maps of all groups, even in the last cut off point, seem to be uncomplicated. In other words, the number of response words associated with the key words were low, and instead of a branching network of key words and their responses, isolated islands of associations were formed. For instance, in the second experimental group's mind map at the cut off point of 10-14, four islands of key words and their few associations were formed.

By using the frequencies of the response words to each key word in the post-WAT, the post-WAT mind maps of all groups were also drawn (Figures 4, 5, and 6) so that a comparison could be made between the pre-WAT and the post-WAT mind maps of pupils, and between the mind maps the instructor had in mind regarding the teaching of the subject matter. As an overall result, comparing with pre-WAT mind maps, it can be said that there is considerable change in all post-WAT mind maps in terms of the maps' quality (i.e., branching, linking between key words, the types and number of response words associated with the key words). Thus, key words have either direct associations or, in a few situations, are linked through other words.

There are some clear differences among the post-WAT mind maps of the groups. In the control group's mind maps, the key words have direct associations; there are no associations made via response words between key words. There are

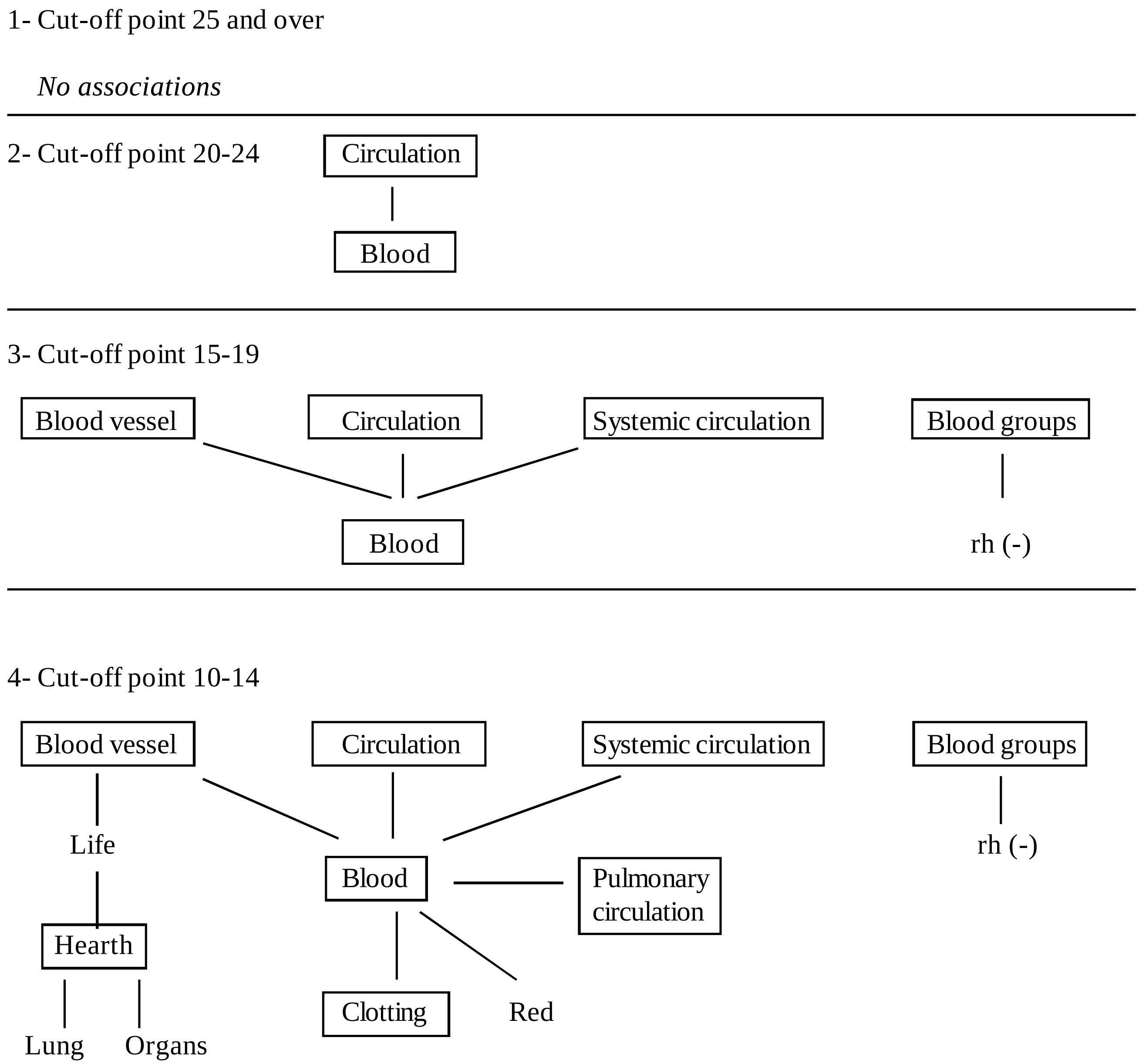

Figure 1. *The pre-WAT mind map of the control group*

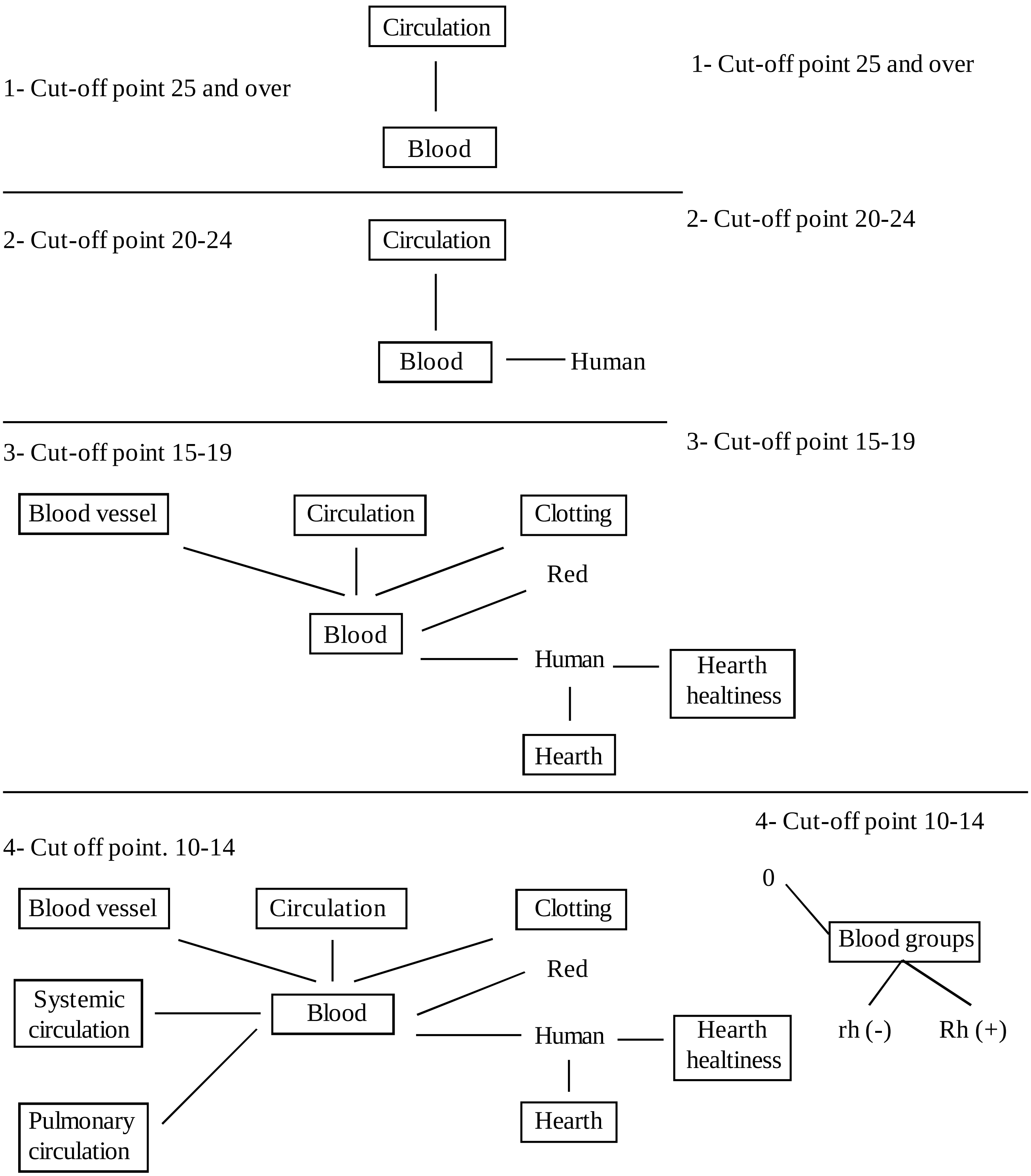

Figure 2. *The pre-WAT mind map of the first experimental group*

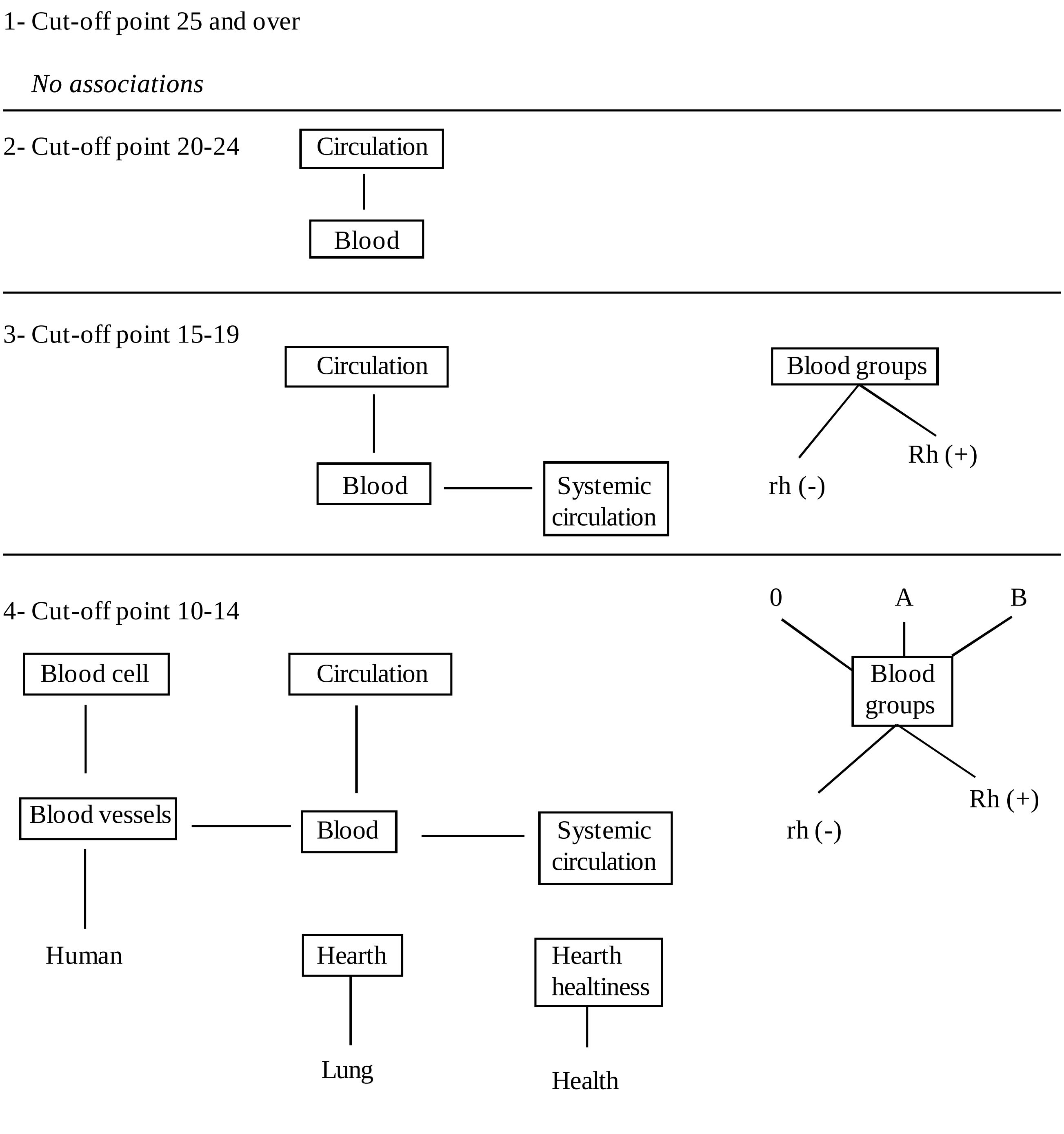

Figure 3. *The pre-WAT mind map of the second experimental group*

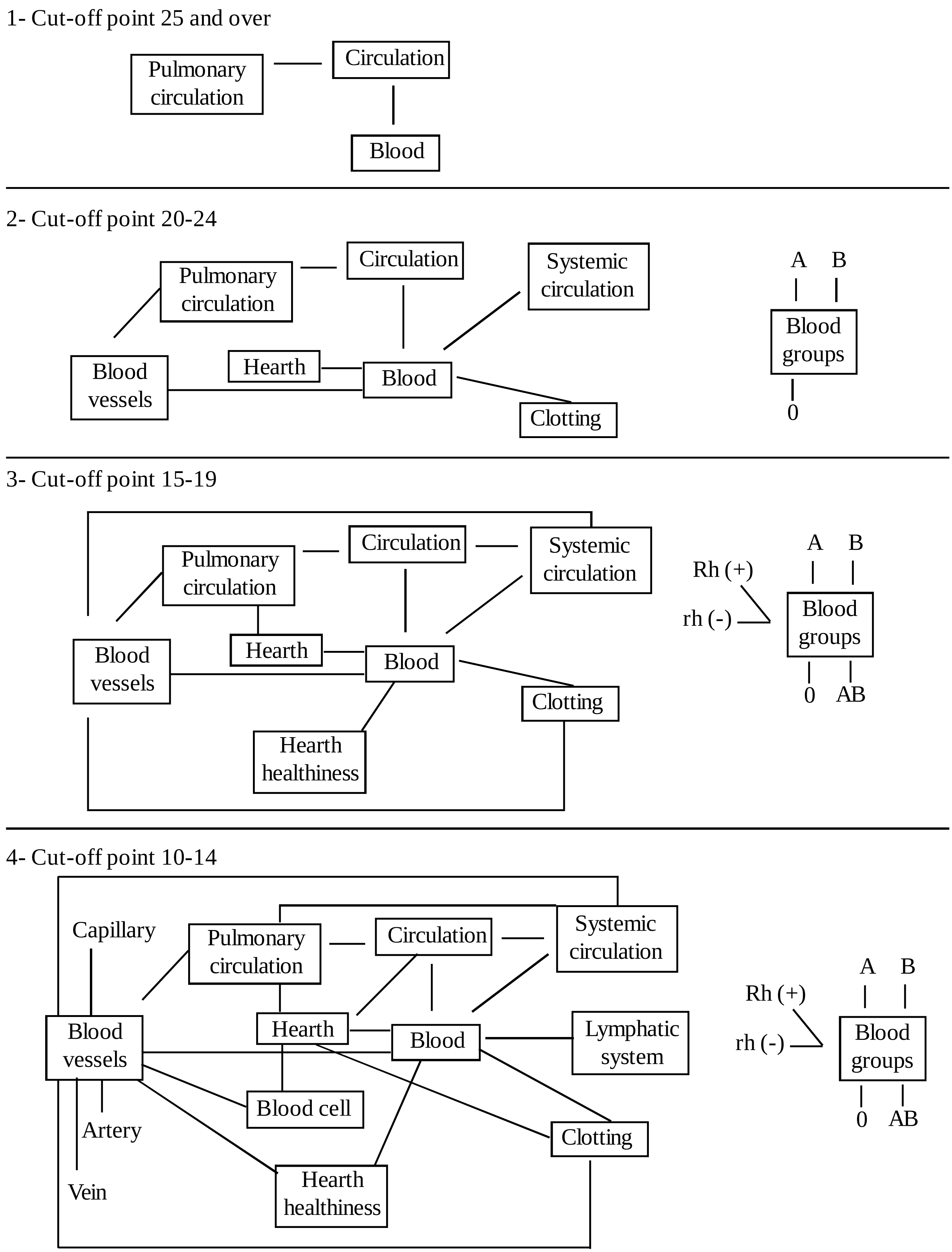

Figure 4. *The post-WAT mind map of the control group*

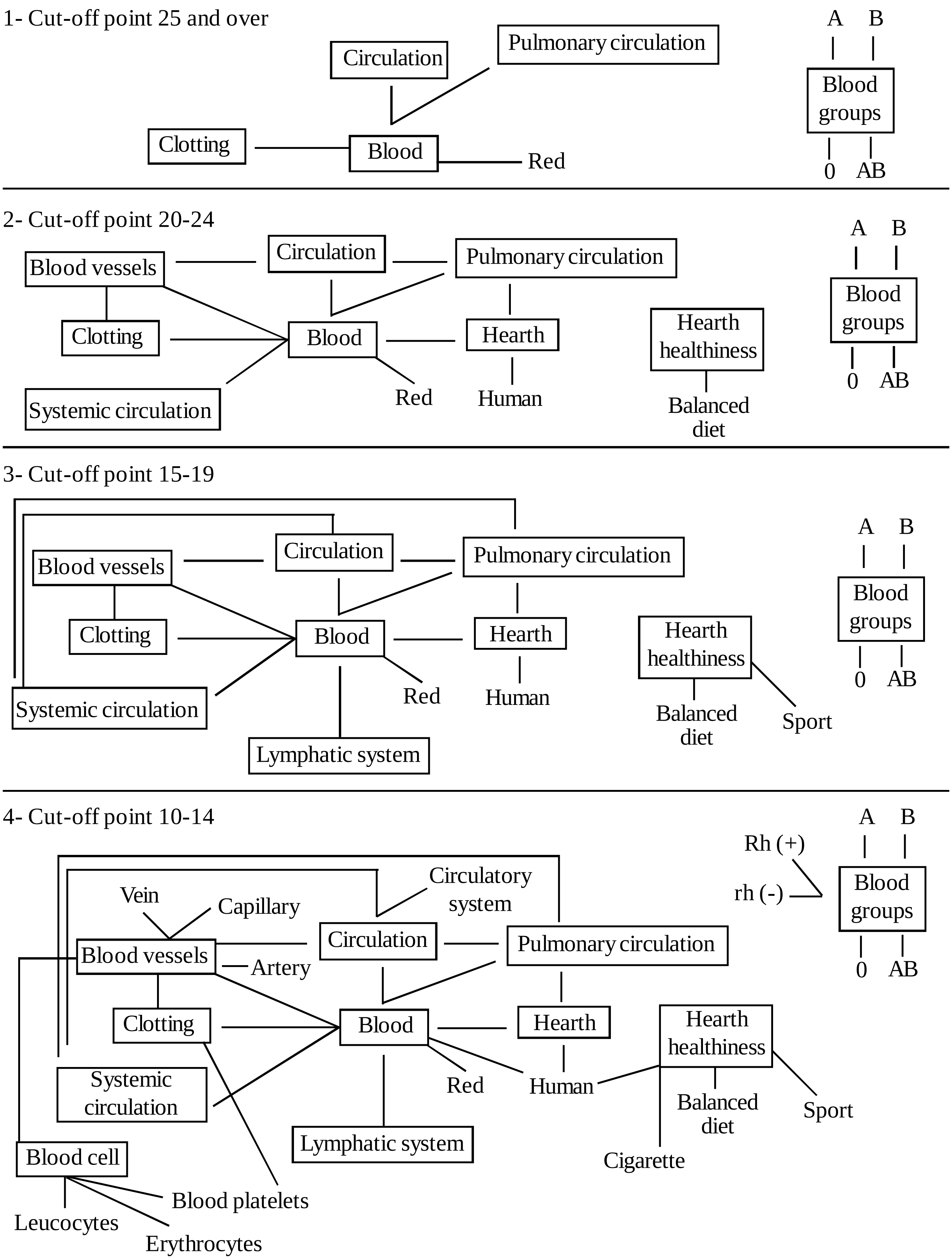

Figure 5. *The post-WAT mind map of the first experimental group*

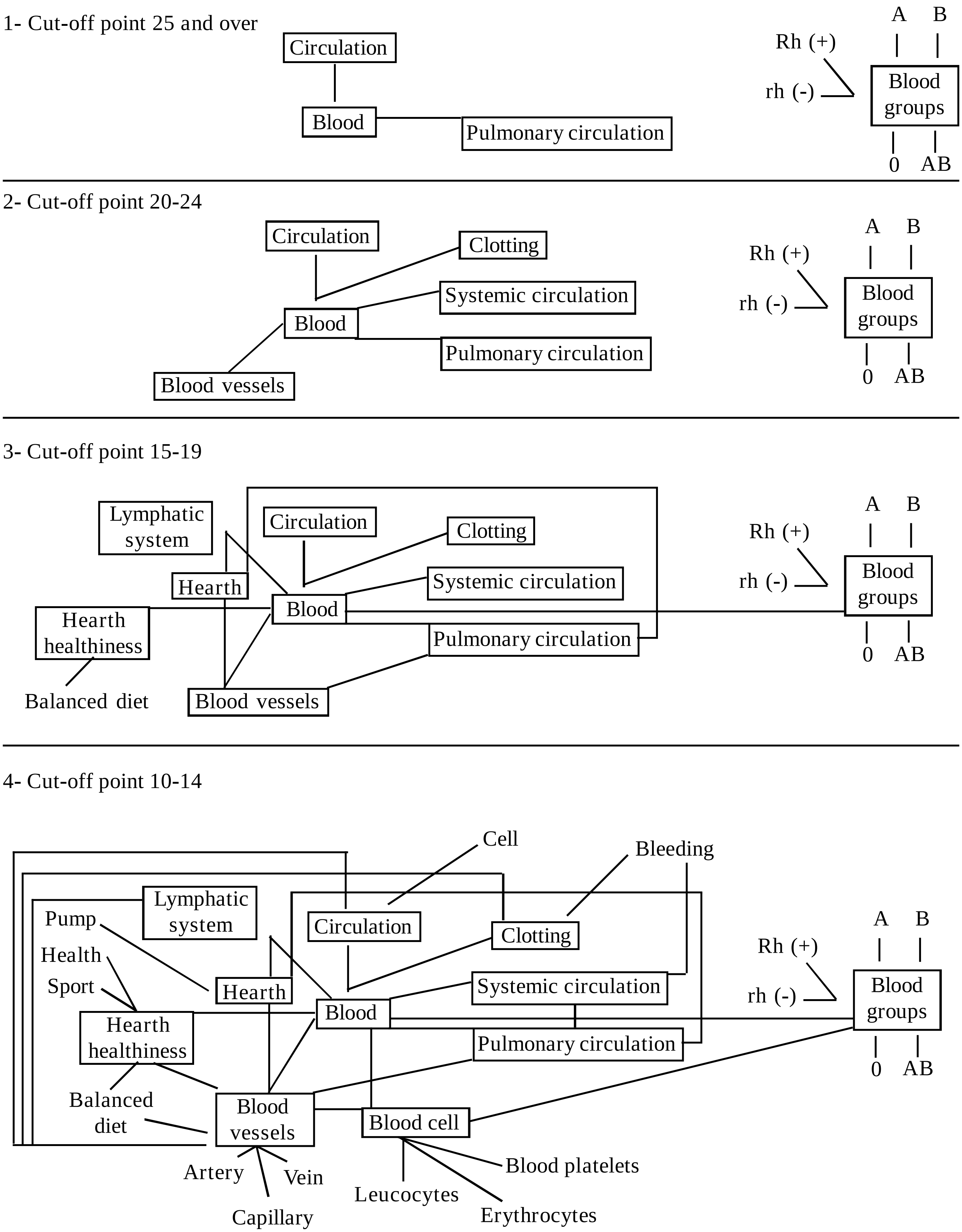

Figure 6. *The post-WAT mind map of the second experimental group*

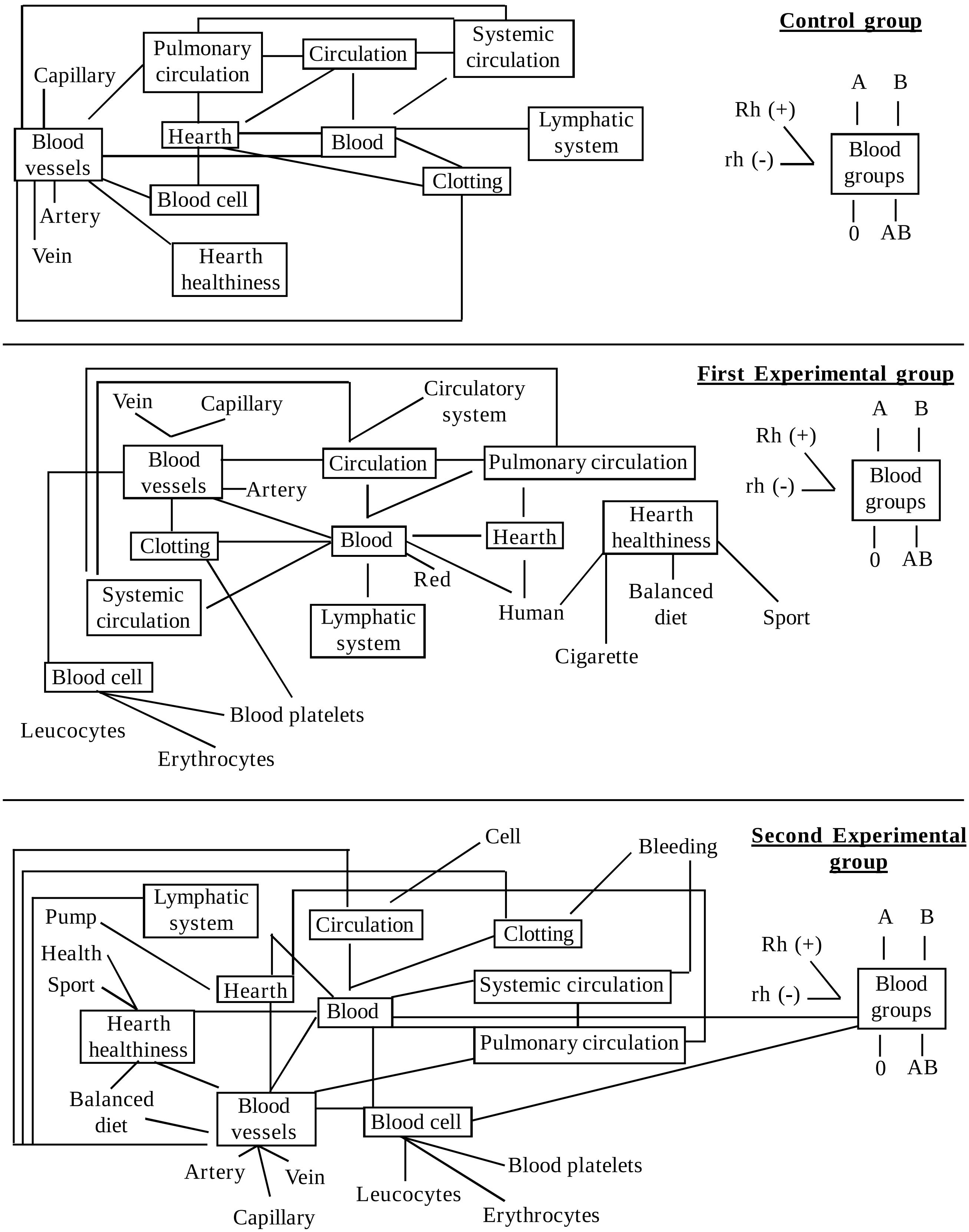

Figure 7. *The comparison of three groups' mind maps at the cut off point 10-14*

only few response words (nine in total) associated with the key words even at the weakest level (i.e., cut-off point of 10-14). On the other hand, in addition to the direct associations, there are also some links via response words in mind maps of both experimental groups. For example, "blood cell" is linked to "clotting" through blood platelets (in the first experimental group), and "heart healthiness" is linked to "blood vessels" through balanced diet, in addition to their being directly linked (in the second experimental group). In both mind maps, the number of response words is the same (eighteen in total) at the cut off point of 10-14. In spite of the similarities between the first and second experimental groups regarding the number of response words associated with the key words and the linking between key words, if one looked at the mind maps of all groups at the cut off point of 10-14, where all key words appeared, the main differences can be clearly seen even in the maps of first and second experimental groups (Figure 7). An examination that starts at the control group's mind map and ends at the second experimental group's mind map enables a keen eye to detect an increasing complexity and branching as well as a network of associations. With a few response words associated with the key words and one isolated island (i.e., blood group) from the main cluster, the control group's mind map is less complicated than the mind map of the first experimental group where different response words were associated with the key words. However, in this map the key word "blood group" also remains an isolated island. A complete and a reasonable network is seen in the second experimental group's mind map where all the key words and their responses are part of a network of linkages. However, it is important to mention that a complete network of ideas at the cut-off point of 10-14 does not mean that at least ten students out of thirty five (sample size for the second experimental group) have this kind of network of the concepts. Each of the ten students, but not necessarily all, might have had some part of the connections in the map. Therefore, all maps for the three groups at the cut off point level of 10-14 produced class pictures. They do not carry direct information for each pupil in the groups.

How may the obvious differences among the groups' mind maps as seen in Figure 7 be explained? As already mentioned in the Method section, the control group was taught using the traditional lecturing approach. In addition to lecturing, concept maps were used in the first experimental group. In the second experimental group, the cooperative learning approach was used. The first difference seems to be related to concept maps since concept maps illustrate how knowledge is arranged in students' minds in addition to showing what knowledge students hold (Kinchin & Hay, 2000). The ability to construct a concept map also illustrates two essential properties of understanding: the representation; and the organization of ideas (Halford, 1993). The construction of a concept map is expected to show the perceptions of an individual, rather than a reproduction of memorized facts (Jonassen, et al., 1997). The structure of a map is, therefore, unique to its creator, reflecting his/her beliefs and biases in addition to his/her understanding of the subject matter. In this study, as a result of these advantages, the concept maps may have helped pupils to reinforce their conceptual links that were fundamental in developing an integrated, branched knowledge structure. Hence, concept maps, as a metacognitive tool, may help the integration of new and existing knowledge since they make the knowledge structures explicit in the mind by being drawn and restructured continuously by individuals as well as by peers or groups in the first and second experimental groups.

In some cases, a particular teaching approach might be strengthened when used together with another approach. In so doing, the weaknesses of that particular teaching approach might be lessened as the advantages of other approaches are added. Also, more pupils who might have diverse learning characteristics may benefit from that modified approach in optimum. This might be the case for the first experimental group where lecturing was used with concept mapping, and for the second experimental group where concept mapping was used in the cooperative learning setting. This thought might be one of the reasons behind the differences among the mind maps of the three groups. It might be logical to claim that, as Kinchin and Hay (2000) stated, by complementing existing best practice (such as collaborative learning strategies), concept mapping will potentially be seen to have a very vital role in promoting meaningful learning and providing teachers with a valuable insight into the mental models of the students.

When the second experimental group was taught using the cooperative learning approach with face-to-face interactions, changing and challenging ideas were dominant. As Gage and Berliner (1991) and Saroyan and Snell (1997) stated, increased participation and attention enhanced memory and learning which may stimulate more associations in the pupils' minds. According to Johnson and Johnson (1999), there is persuasive evidence that cooperative teams achieve higher levels of thoughts and retain information longer than students who work quietly as individuals. The results of this study may support these findings because higher levels of thoughts and longer retention of information may require branched and interconnected network of ideas that promote meaningful learning rather than rote learning.

The active exchange of ideas within small groups can promote critical thinking among the participants. Shared learning gives pupils an opportunity to engage in discussions, take responsibility for their own learning, and, thus, become critical thinkers (Totten, Sills, Digby, & Russ, 1991). The purpose of group work is often to allow students to share and challenge each others' ideas, and this is most likely to occur if members bring different perspectives to their deliberations. If this can be achieved in the classroom by the rapid, non-judgmental comparison of concept map morphology, it may provide a powerful tool to support classroom practice (Kinchin & Hay, 2005).

One of the possible explanations behind the results appeared in the mind maps of the three groups might also be related to the pupils' motivation and interest. As the pupils were taught in different ways, their motivation and interest may have varied. For instance, for the cooperative learning group, the active change of ideas within small groups not only promoted critical thinking but may have also increased interest. It may be logical to claim that pupils' motivation and their active engagement may increase from lecturing to the cooperative learning group. Increased participation and attention may enhance memory and learning which might stimulate more connected and branched network of ideas in the cognitive structure.

As indicated in the Method section, the most common method of analyzing the responses to the key words is to measure the number of common words between responses to pairs of key words and their rank orders. This is attempted in the formula by Garskoff and Houston (1963) to generate a relatedness coefficient, which could range from a value of 1 (perfect relatedness; possibly a synonym) to a value of 0 (totally unrelated). In this study, the cognitive structures of the pupils were probed, and another way of looking for relations that was offered by Bahar et al. (1999) was adopted. However, it is possible to verify the results empirically in future studies by calculating the relatedness coefficient for each key word. By doing so, the responses to the key words could be examined by using two different approaches and the similarities as well as differences could be critically analyzed.

CONCLUSIONS AND TEACHING IMPLICATIONS

In this study, WAT was applied to the pupils before and after sessions on the topic of human circulation system. The findings may suggest that as a result of three different teaching approaches, namely, lecturing, lecturing with concept mapping, and cooperative learning, the pupils' cognitive structures in all the groups changed. The teaching approaches may seem to affect the associations among the concepts in the pupils' minds. Using diverse teaching approaches may have impact on constructing more complex and branching network of ideas. However, as mentioned in the discussion section, it cannot be claimed that the difference between the three groups' mind maps can be solely attributed to the teaching style. As mentioned in the Introduction, concept maps have the potential to help pupils reinforce their conceptual links that are fundamental for developing an integrated, branched knowledge structure. This might stimulate more interconnected response words in the WAT. In conclusion, in the light of the mind maps that were drawn from the frequency of the responses to the key words, it might be said that more complex, branched and interconnected mind maps may be observed as we move from the lecturing approach to cooperative learning. However, the effect of concept maps regarding the associations between the concepts in the mind maps of the first and second experimental groups may not be negligible. Therefore, it would be interesting to carry out a future research study by using three different approaches without using concept maps. By doing so, the effect of the teaching style on the cognitive structure of pupils might be seen more clearly.

The results of this study convey two messages to the teacher: one is related to the WAT, and the other is related to the teaching approaches. In terms of using WAT as an educational tool, the word association test is a powerful technique for revealing the type and the number of the concepts in pupils' cognitive structures as well as the associations among them before and after the session. Teachers can use WAT results (both the number and type of the responses and mind maps) to identify where pupils' strengths and weaknesses are in a content area so that they can focus on what they need to teach. In addition, if the pupils' mind maps are used as a class picture and a reminder of the links they have in mind, this may encourage them to discuss the links so that their understanding can broaden. Like any other techniques, WAT also has some weaknesses. For example, counting the number of responses for each key word and calculating relatedness coefficients can be time consuming. Thus, inferences that are made from responses to the key words might carry some subjective judgments. However, as mentioned before, it is still powerful as a diagnostic tool, and it is easy to write and simple to administer. In five minutes time, it can be conducted in a large group of pupils. It is not claimed that WAT should be applied to each area in a course. However, it can be applied in a unit, at least once, to benefit from the advantages mentioned above.

The results of this study may also suggest that teachers should use more diverse teaching approaches. In such cases, the pupils are actively engaged, and a more interconnected, branched network of ideas can be constructed by them. In this way, meaningful learning, which means that existing knowledge and incoming knowledge interacts with each other and new knowledge structure is actively constructed, is more likely to occur and a positive attitude towards biology may be enhanced.

One may argue that even though the results of this study may suggest using the cooperative learning approach (including concept maps) to stimulate more branched and integrate network of ideas, it is not possible to suggest an ideal combination of teaching approaches that is valid for any situation. Teachers should use more diverse teaching approaches by taking into consideration some factors such as the content of the subject matter, and the individual differences of the pupils among others.

In this study, the post-WAT was applied after a teaching session. Its application after a long period of time may give different associations for the key words. Even the application of WAT before or after an exam period may have an effect on the mind map of the groups. As indicated by Bahar et al. (1999), the WAT is a "snaphot" of pupils at the end of the course; they had not had time to digest it, or revise it. If the pupils may find time to internalize and to revise the subject matter when preparing an essay or before sitting an exam, the connections among key words may show an improvement. Therefore, it would be interesting to repeat the WAT after a period of maturation to reveal the changes that occur. In addition, it might be valuable to apply simultaneously more than one technique with WAT to the same area so that the overlaps and differences might be analysed in terms of revealing the cognitive structures.

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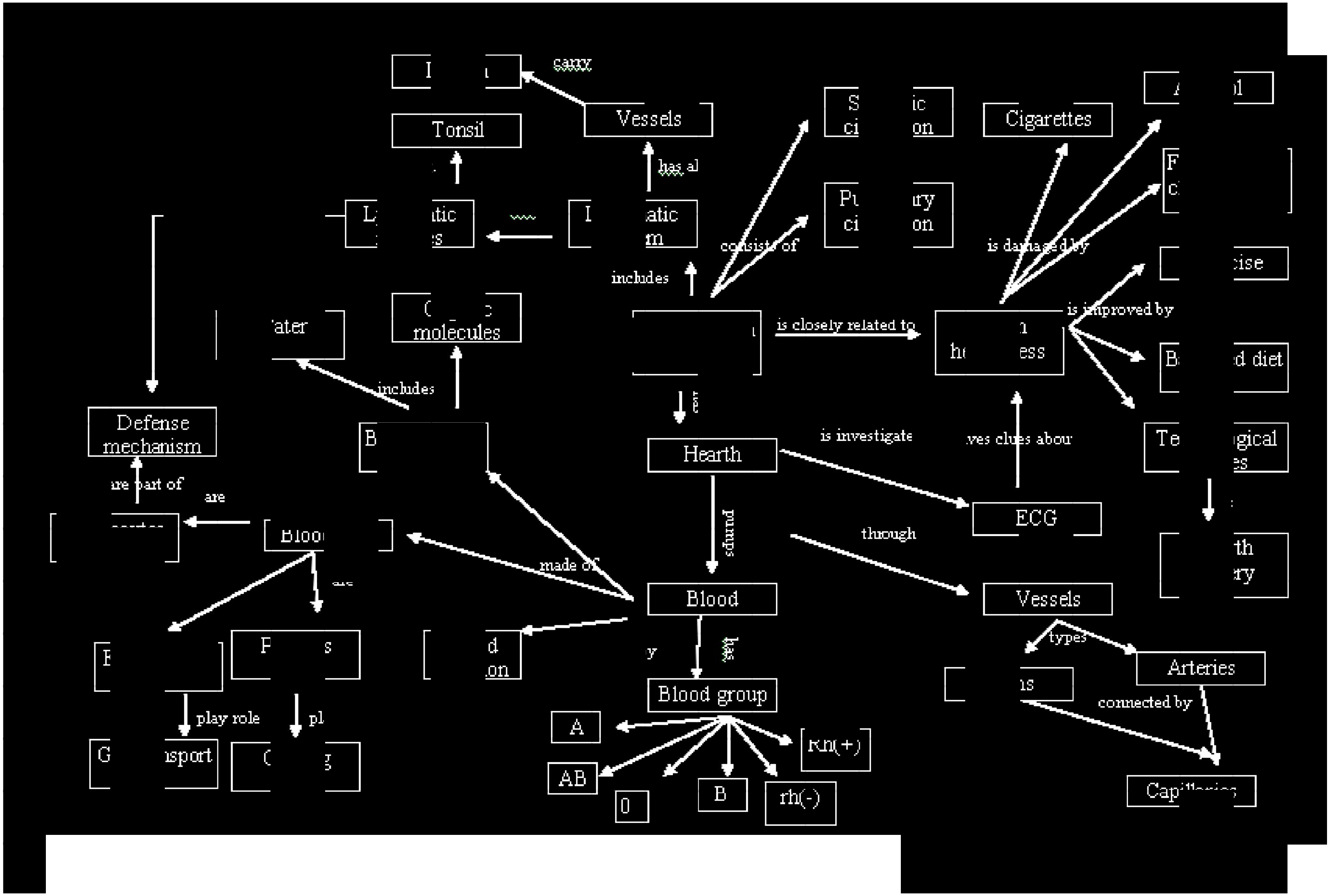
Appendix 1

The general concept map that is constructed by the whole class in the first experimental group



Appendix 2

One of the group's concept map in the second experimental group